Mechanical Effects of Fine-Wire Climbing on the Hindlimb Skeleton of Mice

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High-impact exercise (running/jumping) can stimulate multiple anabolic responses (increased trabecular bone volume, BV/TV) in the skeleton, but is also linked to an increased incidence of skeletal fracture. Thus, it is not an appropriate treatment for patients with elevated fracture risks. However, multi-directional off-axis mechanical loading can also elicit anabolic responses, even when magnitudes are relatively low. This represents a potential alternative to high-impact exercise for improving skeletal mechanical properties. To test this hypothesis, we raised twelve weanling female C57BL/6 mice to 4 months of age in custom enclosures that prevent (control) or require (experimental) manual and pedal grasping while balancing and climbing above narrow wire substrates. At sacrifice, we measured whole mouse bone density (DEXA) and performed architectural (μCT) and mechanical (4-pt bending) analyses of the femur and tibia. Body mass was similar between groups, although exercised mice were leaner (-35% fat mass). Bone mineral density was also similar, while bone mineral content was increased (+7%) in the exercised mice. Femoral midshaft polar moment of inertia was similar between groups, but exercised mice had lower BV/TV (-46%) of the distal femur and greater trabecular spacing (+21%). Exercised femora showed more total displacement (+58%) and post yield displacement (+115%) in bending than controls, and increased material toughness (+40%). Patterns were similar for the tibia. Mechanical data are consistent with high-impact exercise studies, but architectural data are not. Together they suggest that our exercise model may improve bone mechanical properties by redistributing mineral within the skeleton, and not by increasing net bone formation.

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